REMARKS

Claims 2, 3, 14, 20 and 37-40 are pending, and clams 15-19 and 21-25 are withdrawn as being directed to a non-elected species but remain in the application in the event that they can be re-joined. Applicants submit arguments for overcoming the rejections based on the prior art of record and respectfully submit that the present application is in condition for allowance.

**Claim Rejections - 35 USC §103(a)**

> *A. In the non-final Office Action dated October 10, 2008, claims 2, 3, 14, 20, 37 and 38 are rejected under 35 USC §103(a) as being obvious over the publication of Fan et al. titled "Deformation behavior of Zr-based bulk nanocrystalline amorphous alloys" in view of U.S. Patent No. 6,096,640 of Hu.*

Background Information

Foremost, before comparing the present invention and the cited references, an explanation is provided with respect to background on how the present invention was conceived by the inventors relative to conventional technology.

Based on the teachings of conventional technology, bulk metallic glass has been produced by **solidification of metallic glass via melting and casting processes**. For example, see: (i) the sentence bridging columns 1 and 2 on page R3761 of the Fan et al. publication; (ii) page 1, line 30, to page 2, line 15, of the present application, as filed; and (iii) page 678, the first three sentences of Section Two, and page 670-680, all of Section Four and FIG. 2, of the cited Kakiuchi et al. "Golf Club" publication.

Generally speaking, metallic glass is an alloy that is able to become amorphous at cooling rates much slower than those of other known amorphous alloys. For this reason, conventional practice for producing metallic glass directs one of skill in the art to melting and casting

techniques. Research and development efforts at the time of the present invention were directed to discovering metallic glass alloys that were able to become amorphous via melting and quenching techniques <u>**at the slowest possible cooling rate**</u>. At the time of the invention, no one of ordinary skill in the art considered any different method of making a metallic glass alloy, and certainly, no one was considering a different method in which cooling rate was fast.

The present inventors discovered that there are several problems with a bulk metallic glass produced by conventional melting and casting techniques when the bulk metallic glass is to be used as a sputtering target for forming thin films via sputtering deposition for nanotechnology applications. Since the elements constituting the metallic glass forms a three-component system or greater, a sufficient amorphous state is not realized upon solidification and <u>an uneven phase of composition is generated in the crystallized structure when the bulk metallic glass is made to a size required for a sputtering target</u>.

As best explained on page 1, lines 18-25, the present inventors sought a metallic glass sputtering target for forming complex-shaped films for use in the field of nanotechnology, where <u>**even a grain boundary of a formed film provides a problem**</u> in nanoprocessing. Thus, a metallic glass sputtering target that was sought by the present inventors was one that enables the formation of a film without a grain boundary. Accordingly, a sputtering target of requisite size is required to have a crystal structure that is extremely fine and uniform (i.e. of a nano-size ultrafine, uniform structure) if it is to be capable of use in forming films in the field of nanotechnology.

However, when preparing a bulk metallic glass via prior art melting and casting techniques, it was discovered by the present inventors that it is <u>**extremely difficult to control the cooling rate of the molten metallic glass raw material**</u>, and there are cases where the

cooling rate becomes faster than a critical cooling rate. In particular, when preparing a large size bulk body (of a size required for a sputtering target), **a cooling speed gradient will occur in the bulk body, and a part of the bulk will be crystallized easily**. As a result, a part of such bulk body will crystallize, and unevenness will arise in the composition of the bulk metallic glass rendering it completely unusable as a sputtering target for use in forming thin films in the field of nanotechnology.

This is because, when a metallic glass having the above referenced kind of uneven composition is sputtered, deterioration in sputtering characteristics such as the generation of nodules and arcing will occur as a matter of course, the there will be an adverse effect on the uniformity of the film. Such a body could clearly not be used as a sputtering target for forming films used in the field of nanotechnology. However, at the time of the invention, the melting and casting technique was the only conventional manufacturing method used for forming metallic glass. See: (i) the sentence bridging columns 1 and 2 on page R3761 of the Fan et al. publication; (ii) page 1, line 30, to page 2, line 15, of the present application, as filed; and (iii) page 678, the first three sentences of Section Two, and page 670-680, all of Section Four and FIG. 2, of the cited Kakiuchi et al. "Golf Club" publication.

Accordingly, the present invention was devised in order to overcome the foregoing drawbacks in the production of a bulk metallic glass via melting and casting as described above. The present invention produces a sputtering target by an entirely different technique. To this end, the present inventors prepared raw material powder via a gas atomization method and then sintered the obtained powder. This was entirely different to conventional manufacturing methods for bulk metallic glass at the time of the invention.

At the time of the invention, it was difficult to consider by the present inventors that a metallic glass sputtering target produced with powder metallurgy would be able to obtain a sputtering target of the same quality, much less one of improved quality, as the bulk metallic glass produced via melting and casting; rather, it was natural to consider this to be impossible. The results were entirely unexpected. Nevertheless, with the present invention, it became possible to produce a sputtering target that is, not only as good a quality, but of a superior quality to the bulk metallic glass produced via melting and casting. The quality was so good, that it enabled complex-shaped films to be deposited and used in the field of nanotechnology where even a film with a grain boundary is unacceptable.

As described in detail in the specification of the present application, as filed, upon sintering the raw material powder via a gas atomization method, **the cooling rate gradient in the powder is extremely small**, and, even if crystallization occurred, there is a significant advantage in that **the unevenness of the composition will be extremely small**. This is in direct contrast to melting and casting techniques in which the cooling rate gradient is great when casting a body the size required of a sputtering target.

Further, with the present invention, it is possible to minimize the influence on process changes that often occur in commercial manufacturing processes, and a metallic glass having a uniform composition can be prepared stably and repeatedly.

Accordingly, the present invention provides a method that is significantly superior to the prior art melting and casting method and produces sputtering targets **of a quality** not capable of being produced by prior art melting and casting methods. Moreover, this is a sputtering target formed from a new (higher quality) metallic glass, and the present invention provides a novel manufacturing method of such a higher quality metallic glass target.

The Rejection

In the Office Action dated October 10, 2008, the Examiner is refusing the entirety of the present invention by indicating that the present invention could have been easily conceived based mainly upon the Fan et al. patent. The secondary reference, Hu, is merely cited for the disclosure of a sputtering target.

Fan et al.

Fan et al. disclose a method of making an ingot by "arc **melting** the mixtures of pure metals in a purified argon atmosphere and **cast** into a copper mould in vacuum." (See the sentence bridging columns 1 and 2 on page R3761 of the Fan et al. publication.) This method relies on the use of a copper mold to perform arc melting and quenching. This and similar methods are also discussed on page 1, line 30, to page 2, line 15, of the present application, as filed. These bulk metallic glass manufacturing methods are entirely different to that of the present invention.

In addition, Fan et al. manufactures and discloses an ingot or specimen that is of a very small size relative to the size of a typical sputtering target. The specimen of Fan et al. is 2mm in diameter and 4.5 mm long. (See column 2, lines 16-17, of page R3761 of the Fan et al. publication.) Applicants have previously argued, and continue to argue, that known technology for producing bulk metallic glass at the time of the invention does not enable one of ordinary skill in the art to simply increase the size of the specimen to a size required for a sputtering target **while being able to maintain characteristics and uniformity**.

Hu

On column 5, line 60, to column 6, line 2, Hu discloses a tungsten silicide (W-Si) sputtering target in an amorphous phase for depositing a tungsten silicide nitride diffusion barrier. Accordingly, the amorphous sputtering target described in Hu is a high melting point metallic silicide, and as such, the disclosed material and its characteristics are **completely different from the metallic glass alloy of the Fan et al. publication** (and the present invention).

Argument for Patentability

The metallic glass alloy described in Fan et al. is produced based on **melting and casting**, and, as described above, its technical concept is completely different from the present invention. There is no disclosure in Fan et al. regarding the characteristics, conventional problematic issues, and objects to be achieved regarding a metallic glass sputtering target, and the present invention and Fan et al. are not even based on the common technical foundation. Thus, nothing of the present invention is rendered obvious to one of ordinary skill in the art from the teachings of the Fan et al. publication.

Further, Fan et al. provides no description of density. In the present invention, a target having characteristics that are superior to a bulk metallic glass produced by melting and casting is obtained by sintering raw material powder prepared with a gas atomization method; however, this is only true if the target possesses a high relative density of 96.4% or more. Accordingly, density is an important constituent element of the present invention, which is a target formed by sintering raw material powder, not melting and casting. Fan et al. provides no such teaching to one of ordinary skill in the art. From this perspective, it is also evident that the present invention

and Fan et al. do not have the same common foundation by which the present invention could be rendered obvious by the Fan et al. publication.

In addition, focusing solely on the disclosed specimen of Fan et al. (i.e., the specimen that is 2mm in diameter and 4.5 mm long), Fan et al. discloses a metallic glass specimen that comprises a structure that is entirely amorphous except for a few fine crystallites dispersed therein. For example, see FIG. 2 and the discussion thereof on page R3762 of the Fan et al. publication. In contrast, the claims of the present application require a structure having "an average crystallite size of 1nm to 5nm" uniformly throughout the entire sputtering target. Accordingly, there is a clear difference in the alloy structure in a state where **fine crystals are dispersed in an amorphous material** as in the disclosed specimen of Fan et al. and in a state where **the entire structure is formed of fine crystals** as required by independent claims 2 and 37 of the present application. Reconsideration of this limitation and difference between the claimed invention and cited Fan et al. publication is respectfully requested. For at least this reason, Applicants submit that claims 2 and 37 are patentable and non-obvious over Fan et al. in view of Hu.

Moreover, the secondary reference, Hu, is cited to supplement Fan et al. because Fan et al. clearly fails to disclose anything relative to sputtering targets or for forming thin films via sputtering deposition techniques. However, the amorphous sputtering target described in Hu is a high melting point metallic silicide, and this material and the characteristics thereof are completely different from the metallic glass alloy of the Fan et al. publication (and the present invention). Accordingly, Applicants find it impossible to accept the Examiner's judgment that the present invention could have been easily conceived by one of ordinary skill in the art based on the combination of these two references. There is simply no common sense reason for one of

ordinary skill in the art to combine the teachings of Fan et al. and Hu due to the difference of the disclosed materials and their characteristics. Fan et al. fails to disclose sputtering targets, and the sputtering target of Hu is made of a material that differs greatly with respect to metallic glass. Further, the alloy structure of Fan et al. is **fine crystals dispersed in an amorphous material** which differs from **an entire structure formed of fine crystals** as required by independent claims 2 and 37 of the present application. Reconsideration is respectfully requested.

Finally, as previously argued and demonstrated to the Examiner via the previously submitted Declaration of Inoue, a sputtering target of the claimed size having the claimed characteristics cannot be prepared by the prior art melting and casting techniques disclosed by the Fan et al. publication. Known technology as of the date of the present invention does not permit one of ordinary skill in the art to simply increase the size of the Fan et al. specimen (2mm in diameter and 4.5 mm long) **and maintain its characteristics and uniformity**. As stated in the previously filed Declaration, the two manufacturing methods discussed are the only two that would have been known by one of ordinary skill in the art making a sputtering target-sized body at the time of the invention.

For example, as stated in section 4 of the previously submitted Declaration, a sufficiently large amount of Zr-based nanocrystalline amorphous alloy to produce a sputtering target of 100mm is about 324g and **such a large amount cannot be cooled evenly**. The cooling rate will be affected by the coefficient of thermal conductivity of the metal and the length of the path of thermal conductance. When the amount of metal is increased, the length of the heat transfer path in the metal will also increase, and the longer the length of heat transfer path becomes, the greater the thermal resistance will become. Accordingly, as stated by the previously submitted

Declaration of Akihisa Inoue, the required "increase in the amount of metal will become a cause of not being able to manufacture uniform metallic glass."

Thus, it is respectfully submitted that the material produced according to Fan et al. at a size of 2mm in diameter and 4.5 mm long cannot simply be made to a larger size and still have the same characteristics and uniformity as that of the small specimen. Independent claim 2 of the present invention not only requires a sputtering target having a diameter of 100mm or more, but also requires the average crystallite size of 1nm to 5nm to be **uniform entirely throughout the sputtering target**.

Also, when manufacturing bulk metal glass by quenching molten metal, **the cooling speed of the surface of the material forming the ingot that contacts the mold will differ greatly from the cooling speed of material that is embedded deep within the interior of the ingot** spaced from the mold. Accordingly, crystallite size of surface areas of the formed bulk metal glass ingot will differ greatly from that of areas centered deep within the bulk metal glass ingot. In contrast, when sintering gas atomized powder as required by the present invention, there is no temperature difference at outer and inner areas of the sputtering target and crystallite size is **uniform throughout the target**.

Further, cooling speed of the sintered gas atomized powder target of the present invention is fast at $10^3$K/sec. In comparison, cooling speed of the cast ingot of Fan et al. is relatively slow at $10^{-3}$ to $10^1$K/sec. Consequently, with respect to the present invention, it is possible to manufacture a relatively large bulk sintered compact suitable for use as a sputtering target in which the crystal structure of the target is ultrafine and uniform. The same cannot be said for the arc melting and quenching method of Fan et al. which can only form specimens of very limited size having an amorphous structure with a few fine crystals dispersed therein.

For at least the above stated reasons, Applicants respectfully submit that independent claims 2 and 37 of the present application are not obviated by Fan et al. in view of Hu. The present invention provides an advance in the art of metallic glass sputtering targets that is not disclosed, suggested, taught or contemplated by Fan et al. and Hu. One of ordinary skill in the art is not taught by Fan et al. in view of Hu a sputtering target capable of forming thin metallic glass films for use in the field of nanotechnology. Applicants respectfully submit that the invention of claims 2 and 37 of the present application are meritorious and worthy of a patent.

*B. In the non-final Office Action dated October 10, 2008, claims 39 and 40 are rejected under 35 USC §103(a) as being obvious over the publication of Fan et al. titled "Deformation behavior of Zr-based bulk nanocrystalline amorphous alloys" in view of U.S. Patent No. 6,096,640 of Hu and further view of the publication of Kakiuchi et al. titled "Application of Zr-Based Bulk Glassy Alloys to Golf Clubs".*

The Kakiuchi et al. publication discloses melting and casting production methods which are no different than that disclosed by the Fan et al. publication. The alloys formed are for use as golf clubs.

Applicants respectfully submit that one of ordinary skill in the art would have no common sense reason for forming a sputtering target from a material used to form a golf club. However, even if a sputtering target was formed from this material, it would have the same deficiencies and problems discussed above with respect to the material of the Fan et al. publication. Accordingly, all the reasons discussed above for why the inventions of claims 2 and 37 of the present application would not be obvious to one of ordinary skill in the art based on Fan et al. in view of Hu are equally applicable to claims 39 and 40 being nonobvious relative to Fan et al. in view of Hu and further in view of the Kakiuchi et al. publication

For example, the metallic glass alloy described in Kakiuchi et al. is produced based on **melting and casting**, and, as described above, its technical concept is completely different from the present invention. There is no disclosure in Kakiuchi et al. regarding the characteristics, conventional problematic issues, and objects to be achieved regarding a metallic glass sputtering target, and the present invention and Kakiuchi et al. are not even based on the common technical foundation. Thus, nothing of the present invention is rendered obvious to one of ordinary skill in the art from the teachings of the Kakiuchi et al. publication.

Applicants respectfully request reconsideration and removal of the rejection.

**Conclusion**

In view of the above arguments and remarks, Applicants respectfully submit that the rejections have been overcome and that the present application is in condition for allowance. Thus, a favorable action on the merits is therefore requested.

Please charge any deficiency or credit any overpayment for entering this Amendment to our deposit account no. 08-3040.

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